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(56) Documents Cited
GB 2120478 A GB 2059696 A GB 1312318 A
INSPEC abstract of Journal article "Compensation method for frequency offset of received QAM signals in land mobile communications" by Kato et al in Review of the Communications Research Laboratory vol. 39.no.1, p47-52, March 1993, Japan

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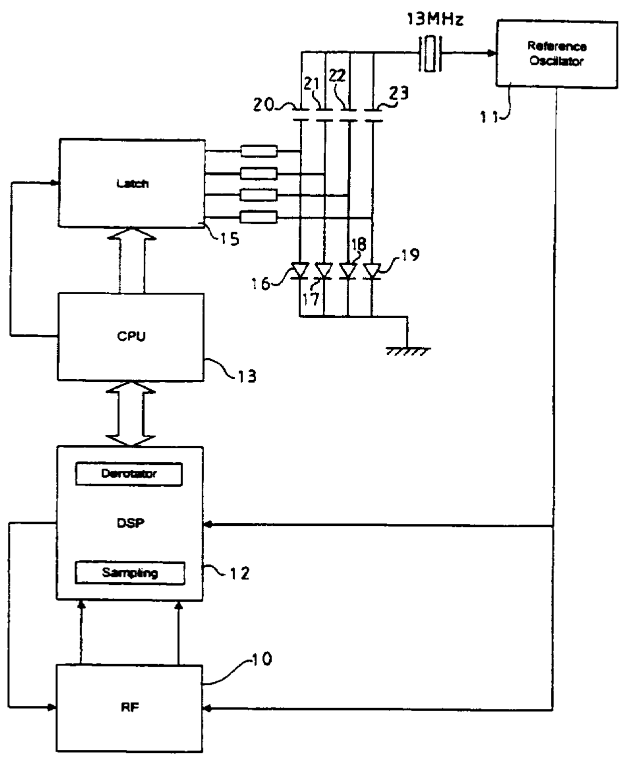
# (54) Hybrid reference frequency correction system

(57) A reference frequency correction system for a digital telecommunications device is shown in the sole Figure. A reference oscillator (11) is associated with a coarse adjustment means (15, 20-23, 16-19) for coarse adjustment of the reference frequency. A DSP (12) includes a frequency error detection means for detecting the frequency error between the reference oscillator output and a received signal. The error signal thus generated is used to control the coarse adjustment means to bring the reference frequency sufficiently close to the received frequency to enable digital correction by derotation of signal samples to be effected by the DSP. Fine correction of the reference frequency is carried out in the DSP(12) by algorithm operations.




At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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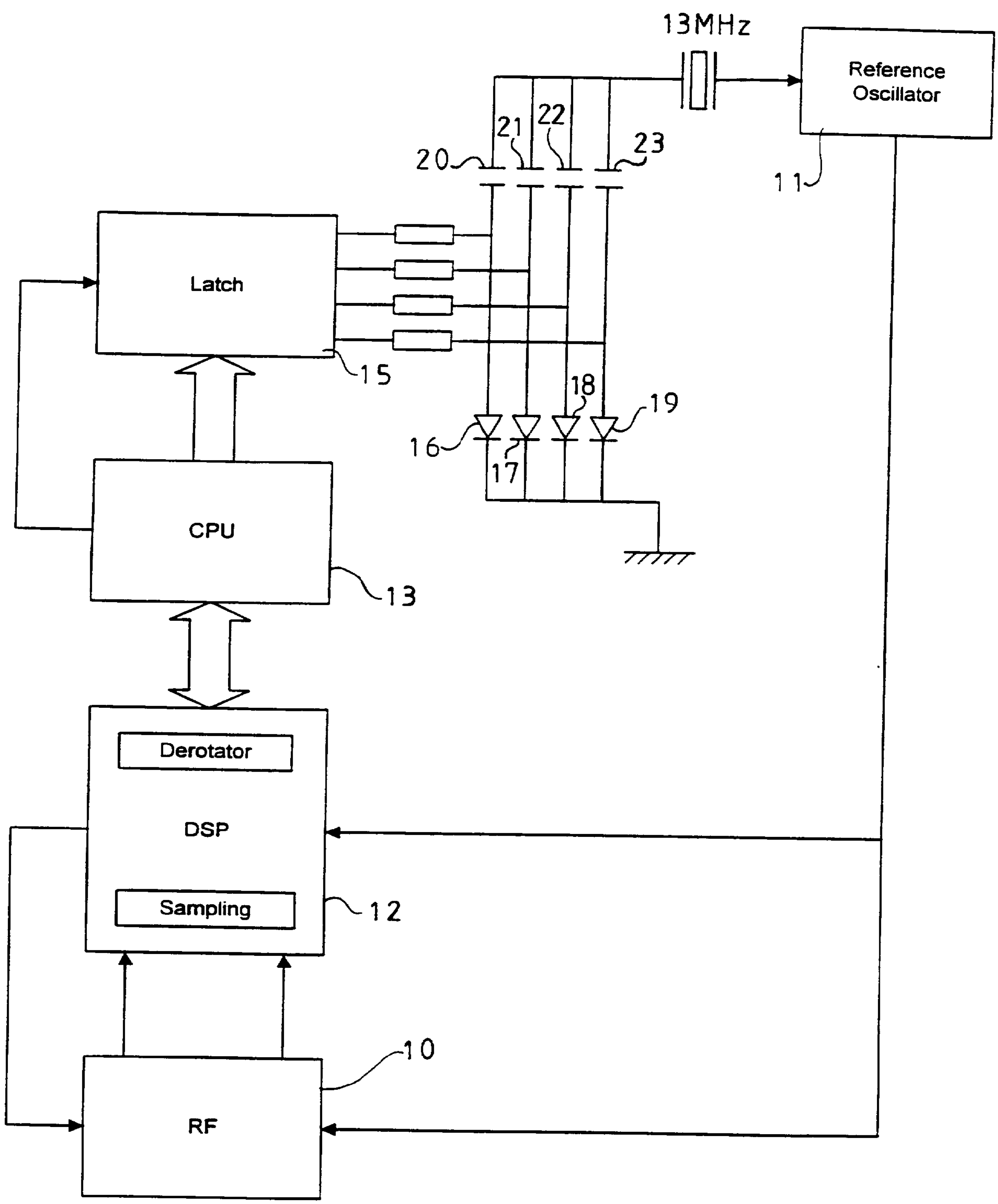
13MHz
Reference Oscillator
11
20
21
22
23
Latch
15
16
17
18
19
CPU
13
Derotator
DSP
Sampling
12
10
RF

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# Hybrid Reference Frequency Correction System

This invention relates to a hybrid reference frequency correction system for use in digital communications equipment such as GSM mobile phones.

In digital communication systems, such as GSM, it is very important to obtain very accurate synchronisation between base stations and mobile stations. Several mechanisms are involved in providing exact synchronisation. Firstly, a frequency correction burst is transmitted in every tenth frame in each 51-frame multi-frame. These are used by the mobile station to achieve coarse synchronisation. Other bursts contain a 64 bit mid-amble synchronisation sequence. All normal bursts contain a 26 bit mid-amble training sequence. These mid-amble sequences are used to keep the mobile station operation tightly synchronised with the base station operation.

The mobile station has a reference frequency source in the form of an oscillator and frequency and phase errors can occur as between signals received from a base station and the local reference frequency both as a result of any inherent difference between the reference frequencies of the base station and the mobile station and as a result of random effects arising from environmental fading.

There exist two distinct basic approaches to frequency correction. Traditionally, the reference oscillator used in a mobile station is a high quality voltage controlled temperature compensated crystal oscillator. This is controlled in accordance with the detected error between the frequencies of the signals expected and those actually received from a

base station. For this purpose, it is necessary to control the oscillator frequency to an accuracy of about 0.1 ppm, so that a very high quality digital-to-analog converter with an external filter is required.

The other known approach to the problem of frequency correction has been to utilise an oscillator which is temperature compensated, but not voltage controlled. Instead, the digital signal processor of the mobile station is programmed with an algorithm which performs a frequency correction operation by de-rotating successive signals, on signals received and on signals to be transmitted. However, the RF stages of the mobile station are also dependent on the reference frequency oscillator, so that to allow proper reception of signals when there is a frequency error occurring, it is necessary to give the various filters in the RF stages a greater bandwidth than would otherwise be needed. This degrades the signal to noise performance of the RF stages. A very high quality temperature compensated crystal oscillator can mitigate this problem but is expensive.

The present invention seeks to avoid the problems raised by the two prior proposals inexpensively, by utilising a hybrid approach in which the reference frequency oscillator is adjusted coarsely in accordance with the detected frequency error, and fine frequency correction is effected in the digital processing of the signals received and those to be transmitted.

An example of the invention is shown diagrammatically in the single figure of the accompanying drawings which show a GSM mobile station to which the invention has been applied.

The RF stages 10 of the mobile station shown include receiving and transmitting sections intended to operate at the GSM carrier frequencies around 900 MHz at 200 KHz intervals. The receiving and transmitting frequencies are synthesized from a 13 MHz reference frequency generated by an reference oscillator 11. In known manner, the RF stages 10 pass to the DSP 12 of the mobile station batches of sample values for the in-phase and quadrature components of the received signals. The DSP processes these samples, which are taken at intervals determined by the reference oscillator.

Where the received batches of samples are taken from synchronisation bursts or normal burst, the DSP processes the samples representing to synchronisation sequence or the training sequence as the case may be and derives a frequency error value which it passes to the CPU 13.

The CPU 13 processes this frequency error signal and outputs a coarse correction signal in the form of a four bit word to a latch 15. The outputs of latch 15 are connected to drive a series of switch devices in the form of PIN diodes 16 to 19, which are respectively in series with four capacitors 20 to 13 of different capacitance values. The four series paths thus provided are connected in parallel with one another between on side of a 13MHz crystal and a ground bus. The crystal forms part of a simple crystal oscillator circuit 11. The frequency of the oscillator can be varied in 16 steps over a range of $\pm 30$ ppm in accordance with the value of the output word of the CPU to the latch 15.

The coarse adjustment of the reference frequency provided by the above described arrangement is sufficient to ensure that normal narrow pass band filters can be used in the RF stages, thereby preventing degradation

of the signal to noise ratio thereof, and fine correction of the reference frequency is carried out in the DSP processing software as in the prior art referred to above.

The DSP also provides digital frequency correction, for correcting the individual sample signals digitally as these are being processed. Since the coarse frequency correction applied to the reference oscillator can correct the frequency error to within $\pm 2$ ppm, the range over which the digital correction within the DSP must operate is relatively small. The frequency error calculated by the DSP from the mid-amble synchronisation or training sequences, is used to control a derotator function which adjusts the relative values of the I and Q components of each data sample before these are processed by decoding algorithms. Derotation to provide frequency error correction of up to 6 ppm is relatively simple to achieve by the known algorithms used in the DSP.

It should be understood that data transmitted undergoes multipath distortion. Channel conditions in a mobile environment are not constant from one frame to the next. The training sequence in each frame is thus used to establish the frequency error for that frame and thus the amount of derotation required for decoding the data bits in that frame.

In actual use of the mobile station, the coarse frequency adjustment is effected at start-up and is latched so that frequent small changes in the frequency error do not cause noisy operation of the oscillator. It may be repeated occasionally when the mobile station is idle (but in communication with a base station) should the error change significantly.

**Claims**

1. A reference frequency correction system for a digital telecommunications device, comprising a reference oscillator, coarse adjustment means for coarse adjustment of the oscillator frequency, frequency error detection means for detecting the frequency error between a received signal and a signal derived from the reference oscillator, reference frequency control means for controlling said coarse adjustment means for controlling the coarse adjustment means in accordance with said frequency error in a sense to reduce such frequency error, and a digital fine frequency correction means operating on signals received and signals to be transmitted so as to minimise the effects of any remanent frequency error.

2. A reference frequency correction system as claimed in claim 1 in which said oscillator has a frequency control crystal, a plurality of capacitors of differing capacitance values connected in circuit with said crystal and a like number of selectively operable switch elements connected to respective capacitors for selecting which ones of the capacitors are in use.

3. A reference frequency correction system as claimed in claim 2 in which said switch elements are PIN diodes.

4. A reference frequency correction system as claimed in claim 3 including a latch circuit for receiving a control word from a CPU forming said reference frequency control means, said latch having outputs connected to respective ones of the PIN diodes.

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Application No: GB 9626207.6
Claims searched: ALL

Examiner: Mr.SAT SATKURUNATH
Date of search: 12 February 1997

# Patents Act 1977
# Search Report under Section 17

## Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H3A: AB, AQA, AQX, ASD, ASX

Int Cl (Ed.6): H03L, H04B, H04L

Other: Online: WPI, JAPIO, INSPEC

## Documents considered to be relevant:

| Category | Identity of document and relevant passage | Relevant to claims |
|---|---|---|
| X | GB 2120478 A STC - see especially figures 1, 2 | 1 |
| X | GB 2059696 A BRITISH - see especially figure 1 | 1 |
| X | GB 1312318 SCHLUMBERGER - see especially figures 1, 2 | 1 |
| A | INSPEC abstract of Journal article "Compensation method for frequency offset of received QAM signals in land mobile communications" by Kato et al in Review of the Communications Research Laboratory vol.39, no.1 p.47-52, March 1993, Japan | 1 |

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| X | Document indicating lack of novelty or inventive step | A | Document indicating technological background and/or state of the art. |
| Y | Document indicating lack of inventive step if combined with one or more other documents of same category. | P | Document published on or after the declared priority date but before the filing date of this invention. |
| & | Member of the same patent family | E | Patent document published on or after, but with priority date earlier than, the filing date of this application. |